Effects of projected climate change on energy supply and demand in the Pacific Northwest and Washington State

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Agriculture/Economics



Coasts



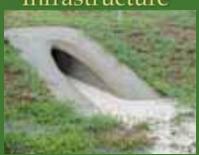
Forest Resources



Human Health



Infrastructure



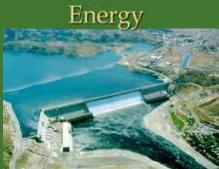
Water Resources



A comprehensive climate change impacts assessment for Washington State



Adaptation

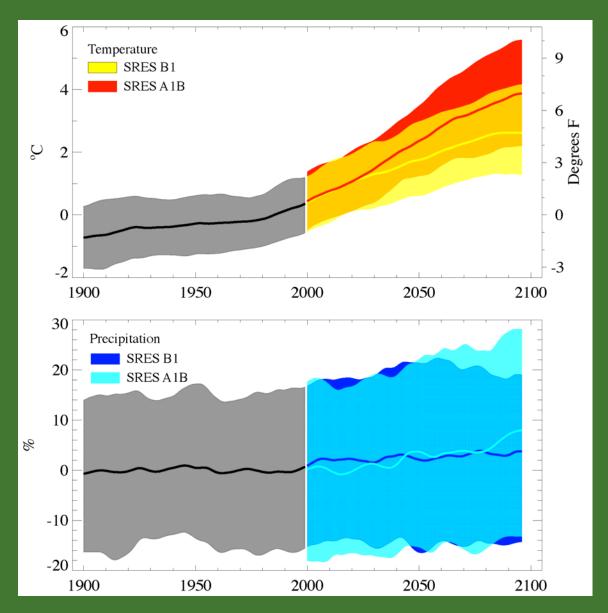


Salmon



Global Climate Change Scenarios for the PNW

21st Century Climate Impacts for the Pacific Northwest Region



Mote, P.W. and E. P. Salathe Jr., 2009: Future climate in the Pacific Northwest

Part I: The Columbia River Hydro System



Importance to the Pacific Northwest:

- Supplies 70% of the Region's Electricity
- •Is primarily responsible for the relatively low cost of energy in the PNW
- Strongly affects local energy supplies in WA

Snapshot of Snohomish Co. PUD

Customers (a/o 12-31-07)

Residential: 283,927
 Commercial: 28,446

Industrial: 78

· Other (street lighting, temporary lighting, etc.): 316

Total Customers: 312,767

Generating capacity (Jackson Hydroelectric Project, Everett Cogeneration Facility): 164 megawatts (MW)

Average number of employees (a/o 12-31-07): 881

Energy sales (a/o 12-31-07): 8,255,135 megawatt-hours (MWh)

Operating revenues (a/o 12-31-07): \$596,174,000

2007 Power purchases:

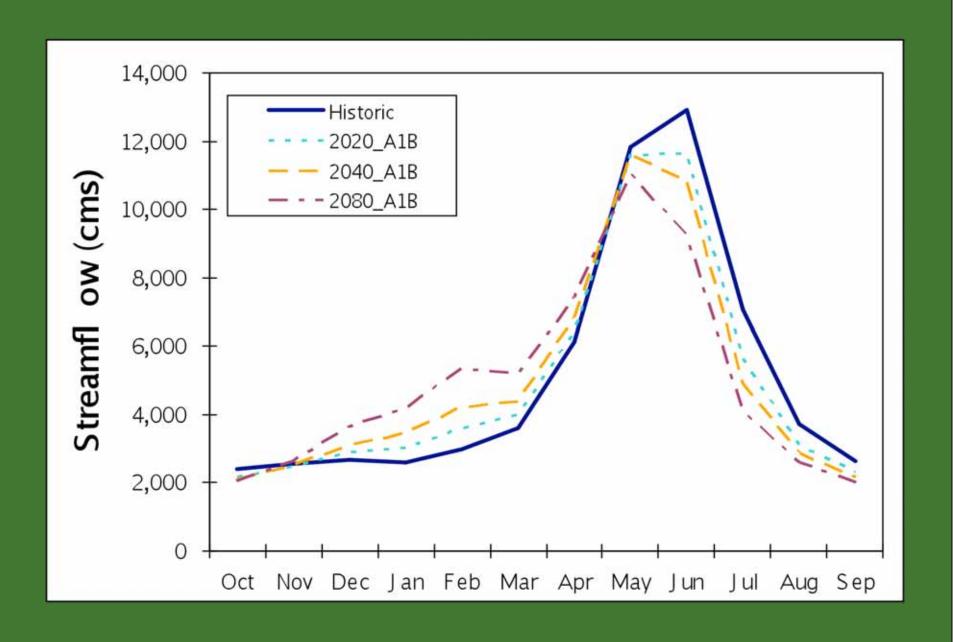
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Bonneville Power Administration	88%
Jackson Project	5%
Long-term Contract Purchases	5%
Market Purchases (Net)	2%
Everett Cogeneration & Hampton	1%
Klickitat Landfill Gas	1%

2007 Fuel mix:

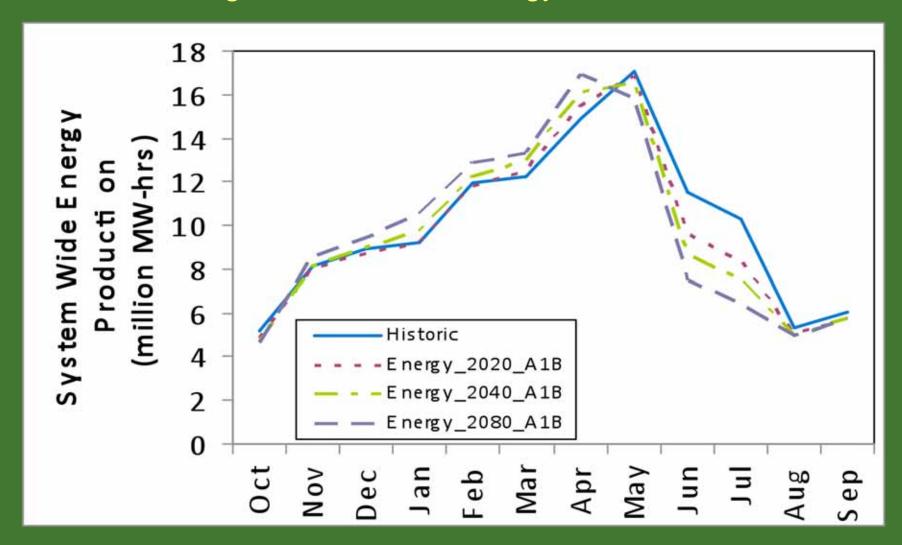
Washington state law requires utilities to publish their fuel mix for customers. The chart below indicates the types of fuel sources the PUD used during 2007:

Biomass	1%
Coal	6%
Hydroelectric Generation	81%
Natural Gas Generation	2%
Nuclear Generation (BPA-supplied)	9%
Other Generation	1%

Changes in Modified Flow in the Columbia River at The Dalles, OR

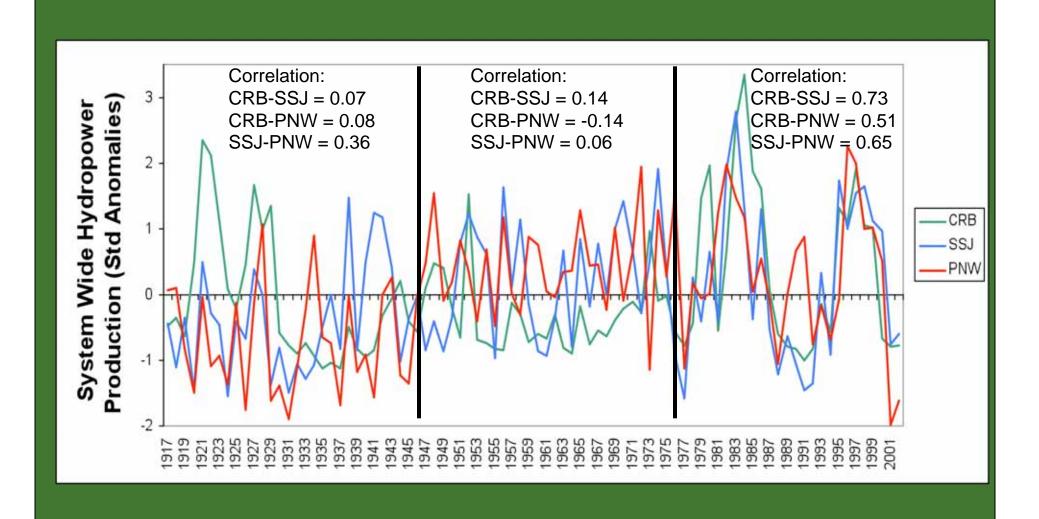


Streamflow Timing Shifts in the Columbia River Will Impact Regional Electrical Energy Production



Hamlet et al., 2009: Effects of Projected Climate Change on Energy Supply and Demand in the Pacific Northwest and Washington State

Simulated Changes in System Wide Energy Production in the Western U.S.



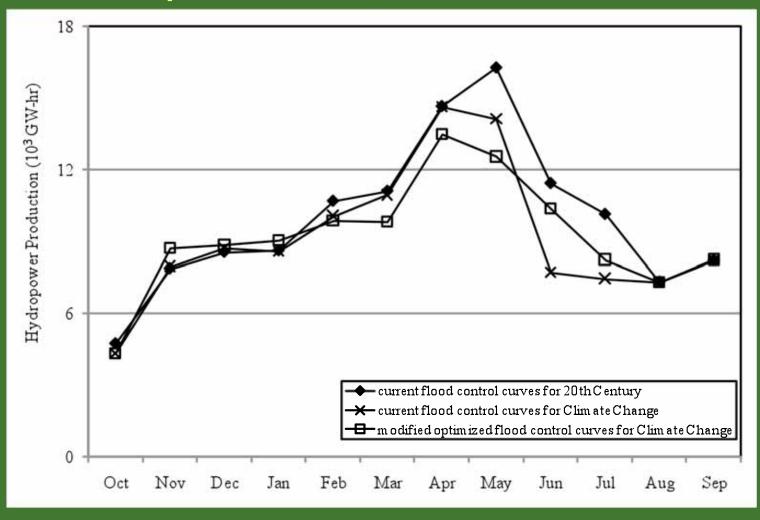
Important Adaptation Considerations:

Climate change will increasingly disrupt the existing balance between hydropower, flood control, and instream flow augmentation in the basin, requiring adjustments in reservoir operating policies.

Transboundary relationships between ID, WA, OR and between Canada and the U.S. will be impacted, requiring potential adjustments in transboundary agreements such as the Columbia River Treaty.

Losses of summer energy production may have important inter-regional impacts because of loss of local capacity and reduced ability to provide energy transfers to CA and the southwest in summer.

Prospects for Adaptation via Optimized Flood Control



Lee, S.Y., A.F. Hamlet, C.J. Fitzgerald, S.J. Burges, 2009: Daily Time Step Refinement of Optimized Flood Control Rule Curves for a Global Warming Scenario, J. *ASCE J.* Water Resources Planning and Management (in review).

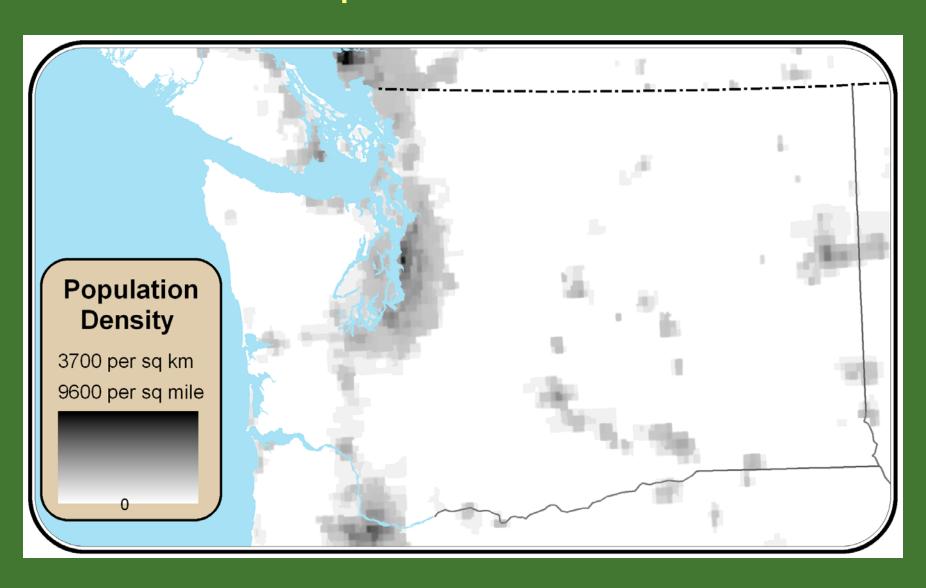
Conclusions:

- •2020s: regional hydropower production is projected to increase by 0.5-4% in winter, decrease by 9-11% in summer, with annual reductions of 1-4%.
- •2040s: hydropower production is projected to increase by 4.0-4.2% in winter, decrease by about 13-16% in summer, with annual reductions of about 2.5-4.0%.
- •2080s: hydropower production is projected to increase by 7-10% in winter, decrease by about 18-21% in summer, with annual reductions of 3.0-3.5%.
- •The largest and most robust changes in hydropower production are projected to occur from June-Sept, during the peak air conditioning season.

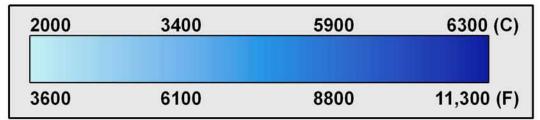
Part II: Changes in Primary Energy Demand for Space Heating and Cooling Needs

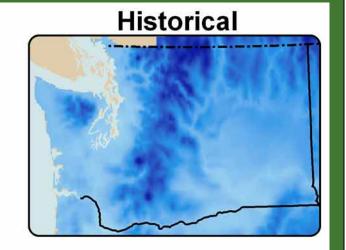
- •Is a fundamental driver of residential and light commercial energy demand
- Strongly influenced by climate via temperature (heating and cooling degree days)
- •Has important implications for individuals, utilities, and high-level planning at both regional and inter-regional (west-wide) scales

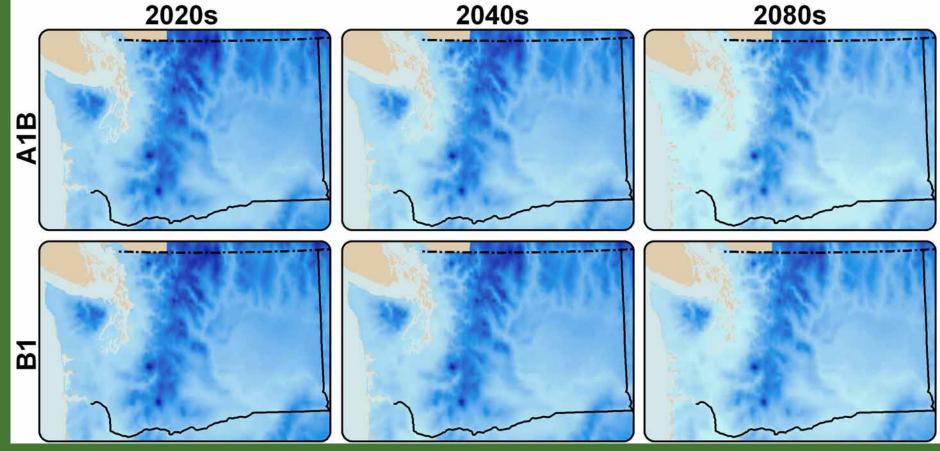
Combined Growth Management Act and Gridded Pop of the World v3 Data Sets

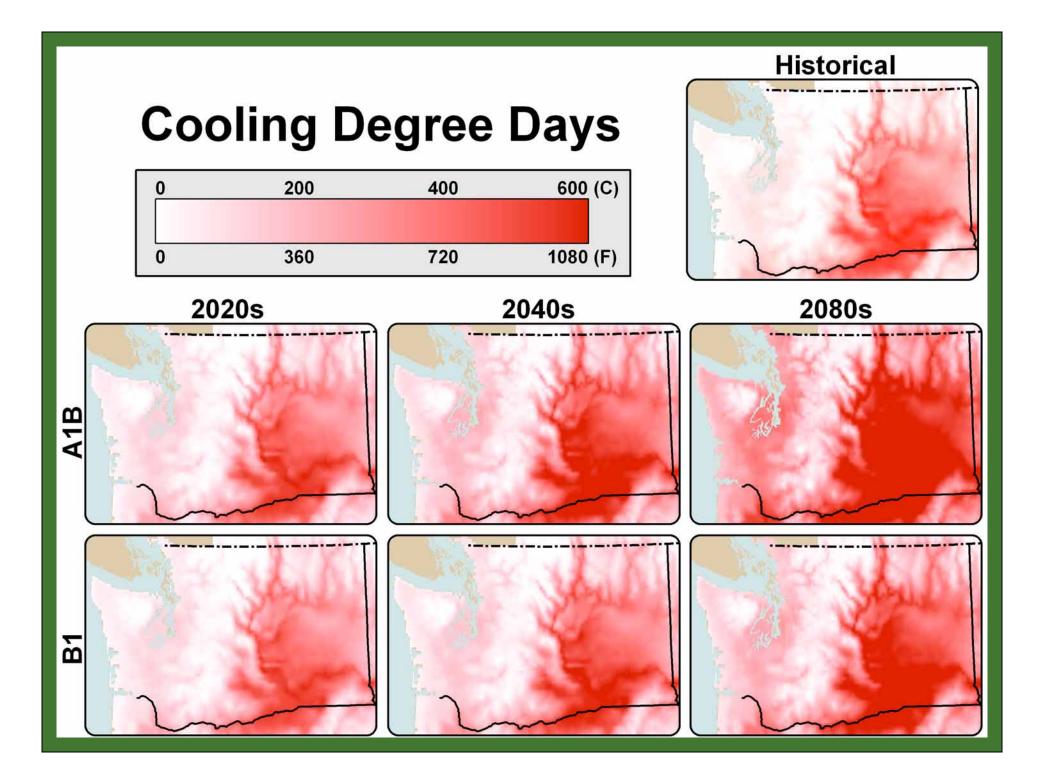


Heating Degree Days









D.J. Sailor, A.A. Pavlova / Energy 28 (2003) 941-951



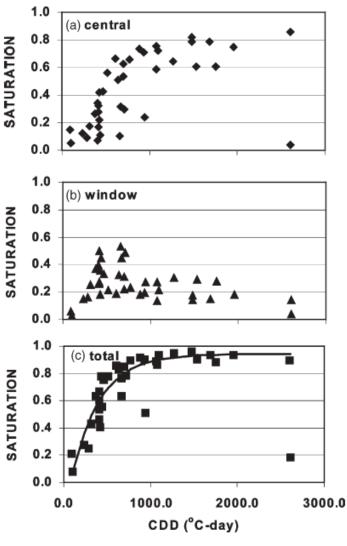
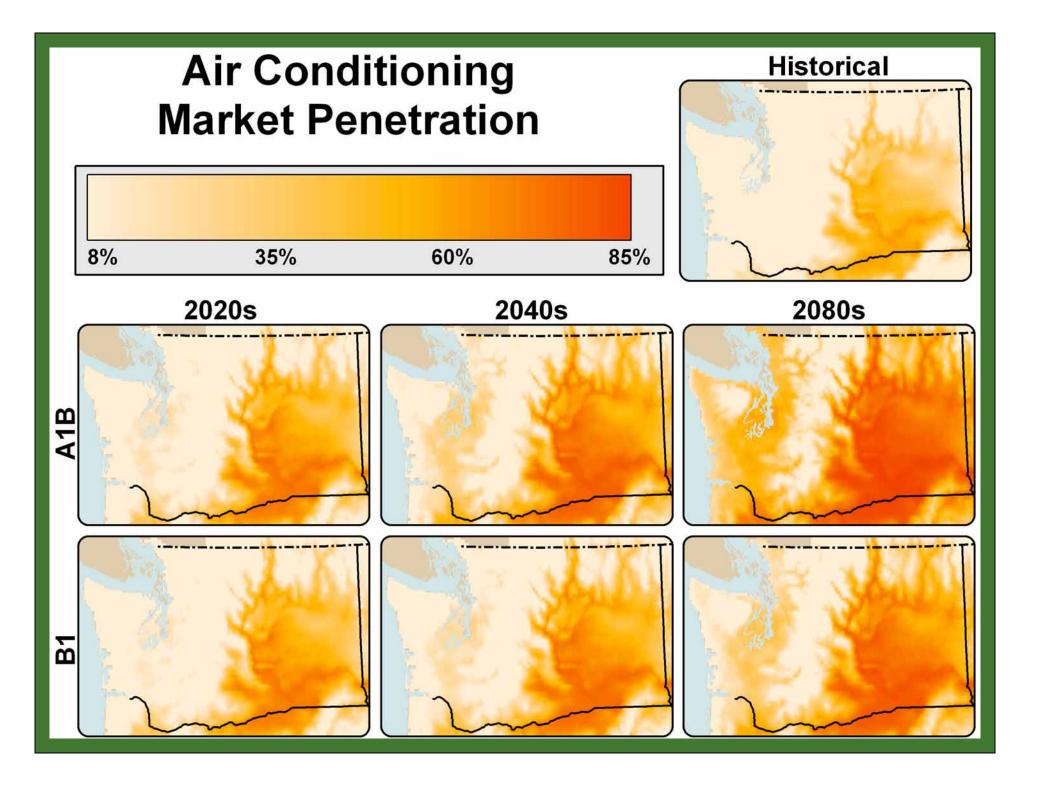
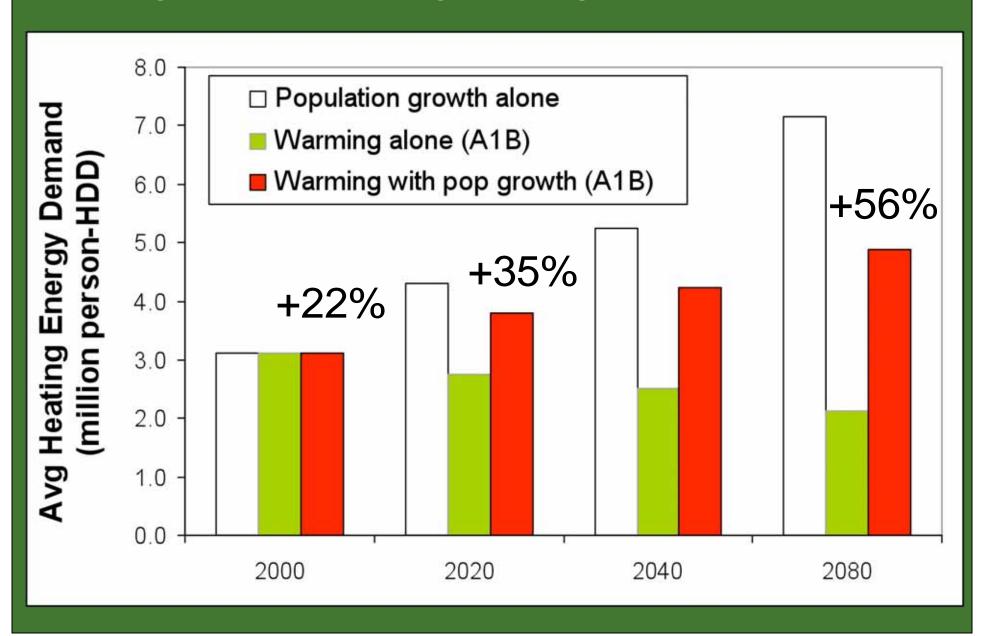


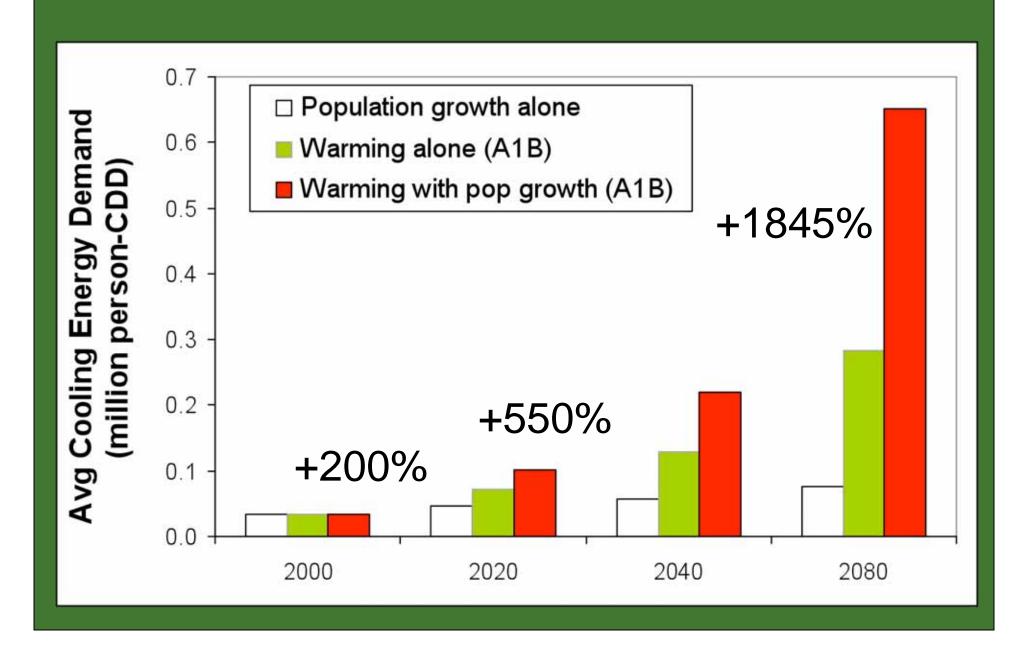
Fig. 1. Residential market saturation for (a) window, (b) central, and (c) combined implementations of air conditioning for 40 US cities. The curve fit in (c) is defined by Eq. (4) and excludes the outlier city of Honolulu.



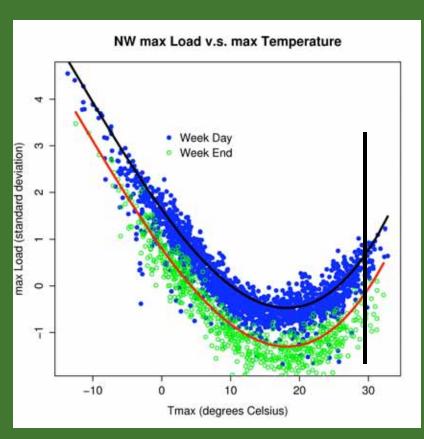
Changes in Heating Energy Demand in WA

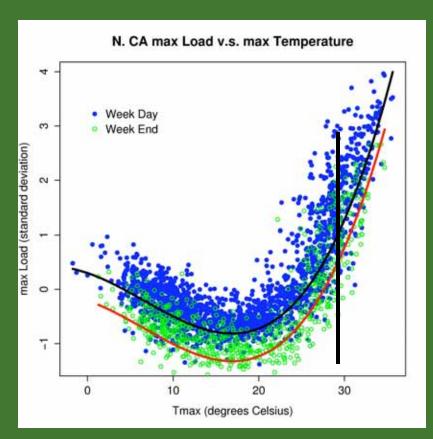


Changes in Residential Cooling Energy Demand in WA



Comparison of Peak Demand in the PNW and N. CA





Westerling A, Barnett T, Gershunov A, Hamlet AF, Lettenmaier DP, Lu N, Rosenberg E, Steinemann AC (2008) Climate forecasts for improving management of energy and hydropower resources in the western U.S., California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2008-XXX

Conclusions

- •Despite decreasing heating degree days with projected warming, annual heating energy demand is projected to increase due to population growth.
- •Residential and commercial cooling energy demand is projected to increase rapidly due to increasing population, increasing cooling degree days, and increasing use of air conditioning.
- •Peak electrical demands in summer will likely increase due to increased population, CDD, and A/C penetration in the PNW.

Inter-Regional Coordination Issues:

The combination of losses of summer energy production from hydropower sources and increasing summer demand in the PNW are likely to reduce the ability to provide energy transfers to CA and the SW in spring and summer. Development of other energy source technology could potentially mitigate these impacts.

Depending on future energy development choices, changing climate could also increase excess capacity in CA in cool season in the future, which might facilitate increased transfers from CA to the PNW at that time of year.